TrueSecure™
GTM-5110Cxx Series
Embedded Fingerprint Module

Revision: V1.10 Date: October 14, 2014

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Table of Contents

1 Features

- Single chip fingerprint recognition module
- Complete integrated algorithms for learn, login and erase functions
- Advanced optical technology
- High accuracy and high recognition speed
- Ultra-thin optical sensor
- 1:1 verification and 1:N identification
- Downloadable sensor fingerprint image
- Fingerprint templates can be read/written to module
- UART communication protocol for interfacing to external master MCU
- Easy fingerprint recognition product integration

2 Applications

- Notebook computer login
- Household security products
- Vehicle entry systems
- Biometric identification products

3 Selection Table

The range of devices shown in the selection table are similar in function, but differ mainly in their fingerprint storage capacity, mechanical construction, pixel count, rotation range etc.

Part No.	Effective Area (mm^2)	Resolution (DPI)	Image Pixels	No. of Fingerprints	Rotation (Degree)	Template Byte Size	Compare Time - sec	Dimension (mm^3) (W×D×H)
GTM-5110C2	14×12.5	450	240×216	20	360	506	1.5	17×37×7.74
GTM-5110C21								21×36.1×7.74
GTM-5110C3	14×12.5	450	258×202	200	360	498	1	17×37×7.74
GTM-5110C31								21×36.1×7.74
GTM-5110C5	14×12.5	450	258×202	2000	360	498	1.5	17×37×7.74
GTM-5110C51								21×36.1×7.74

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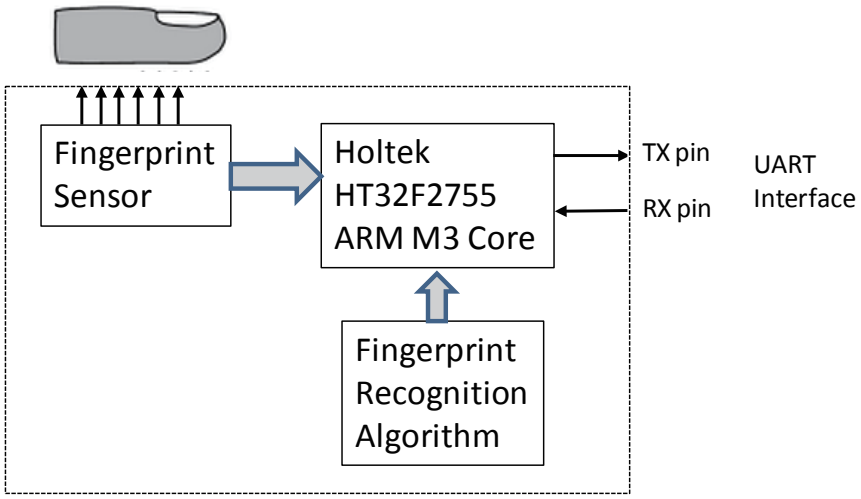
4 Block Diagram

The following shows a simplified version of the internal functions of the fingerprint module.



5 General Description

Fingerprint recognition technology provides a secure and accurate means of biometric identification. This range of device from offers users a quick and easy implementation method for biometric fingerprint recognition. The integration of an optical fingerprint sensor, Holtek 32-bit ARM core microcontroller and fully programmed algorithm into a single module together combine to form complete fingerprint recognition module. A number of fingerprint images or templates are stored within the devices internal Flash Memory and therefore retain storage when power is removed. The storage capacity varies according to the module type selected. With easy commands such as learn, login and erase, this range of device offer a convenient and easy to use solution for users wishing to implement fingerprint biometric security into their products.

6 Pin Description

The fingerprint modules have a very simple 4 pin structure with two pins for power and the remaining two for the UART communication.

Pin No.	Pin Name	Function
1	TX	UART transmit pin
2	RX	UART receive pin
3	GND	Ground pin
4	VCC	Power Supply

7 Electrical Specifications

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{DD}	Operating Voltage	—	3.3	5.0	6.0	V
I_{DD}	Operating Current	No output pin load	—	—	130	mA
V_{IL}	RX input low voltage	—	—	—	0.8	V
V_{IH}	RX input high voltage	—	0.8 V_{DD}	—	—	V
V_{OL}	TX input low voltage	I_{OL} = TBD	—	—	0.4	V
V_{OH}	TX input high voltage	I_{OH} = TBD	2.9	—	—	V
I_{OL}	TX port sink current	—	8	TBD	TBD	mA
t_{SST}	System start up time	—	500	—	—	ms
RR_{VDD}	VDD rise rate	—	TBD	—	—	V/ms
BR_{PON}	Power-on Baud Rate	—	TBD	9600	TBD	Hz

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8 Other Specifications

Item	Value
Communication Interface	UART
Matching Mode	1:1, 1:N
False Acceptance Rate – FAR	< 0.001%
False Rejection Rate – FRR	< 0.1%
Enrollment time	< 3 sec (3 fingerprints)
Operating Environment Temp	-20°C ~ +60°C
Operating Environment Humidity	-20% ~ 80%
Storage Environment Temp	-20°C ~ +60°C
Storage Environment Humidity	10% ~ 80%

9 Functional Description

These fingerprint recognition modules, by integrating a fingerprint sensor, 32-bit Holtek microcontroller and complete algorithms contain all the necessary hardware and software for full implementation of fingerprint recognition functions. The user has only to communicate with the fingerprint module using its UART interface to communicate with the internal hardware and to implement functions such as learn, erase and login.

This set of devices communicates to the outside world via its internal UART interface. This would normally be communication with an external UART interface equipped microcontroller.

Hardware Description

It is through an internal UART interface that the fingerprint module communicates with external microcontrollers. There are two pins associated with the UART, one for data transmission, the TX pin, and one for data reception, the RX pin. Both TX and RX pins have CMOS structures.

At power on the internal hardware will require a specific amount of time to initialise before commands can be received over its UART interface from external hardware. This time is specified in the electrical specifications. No command can be issued to the fingerprint module during this period. Note also that a specific minimum power supply rise time is also required to ensure a proper power on and initialise sequence.

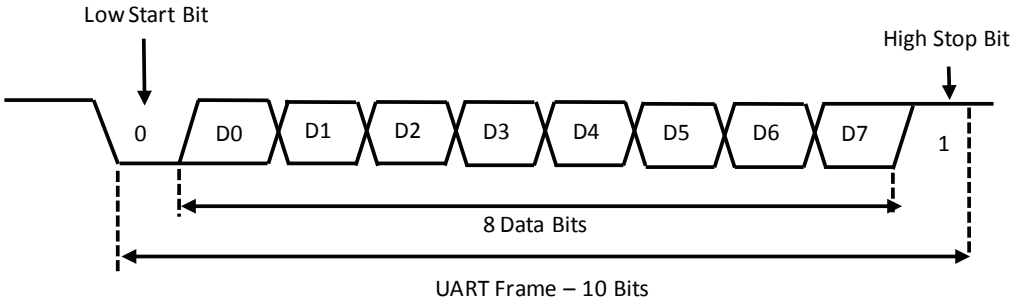
Communication Protocol

The fingerprint modules communicate with external hardware such as microcontrollers using a fully internal UART interface. UART, means Universally Asynchronous Receiver Transmitter, and is a very popular and easy to use communication method.

Universal Asynchronous Receiver/Transmitter – UART

It is through the UART interface that the fingerprint module communicates with external hardware. There are two pins associated with the UART, one for data transmission, the TX pin, and one for data reception, the RX pin. The UART interface sends a byte serially over time, with an indication of start and end of a byte, in the form of start and stop bits, at a particular speed setup by the Baud Rate. After power on the Baud Rate will default to a fixed value but can be later modified using a UART command.

Using this UART interface, an external microcontroller can communicate with the fingerprint module by sending a fixed range of commands transmitted in packets. Within each UART frame the data is preceded by a zero start bit and terminated by a high stop bit. There is no parity bit in the UART frame.



The fingerprint module UART interface contains its own internal Baud Rate generator. When the device is first powered on this Baud Rate will be set to a default value of 9600 Hz. as specified in the electrical characteristics. This Baud Rate can be changed to a different value using an externally requested command sent over the UART interface to match the communication rate of the master MCU. As the data communication is asynchronous the transmitter and receiver do not share a common clock.

Checksum Generation

For each transmission, whether it be command, acknowledge or data, at the end of each data packet, a checksum is generated. This is calculated by a simple addition of all the transmitted bytes as follows:

$$\text{Checksum} = \text{OFFSET}[0]+\ldots+\text{OFFSET}[4+N-1]$$

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Packet Types

There are three packet types which are command, acknowledge and data. Multiple-bytes are ordered using Little Endian. This is to say that the least significant bytes are stored in the lowest addresses.

Offset	Content	Size	Description
0	0x55	BYTE	Command start code1
1	0xAA	BYTE	Command start code2
2	Device ID	WORD	Device ID: default is 0x0001, always fixed
4	Parameter	DWORD	Input parameter
8	Command	WORD	Command code
10	Check Sum	WORD	Check Sum (byte addition) OFFSET[0]+…+OFFSET[9]=Check Sum

Command Packet Description

Offset	Content	Size	Description
0	0x55	BYTE	Response start code1
1	0xAA	BYTE	Response start code2
2	Device ID	WORD	Device ID: default is 0x0001, always fixed
4	Parameter	DWORD	Response == 0x30: (ACK) Output Parameter Response == 0x31: (NACK) Error code
8	Response	WORD	0x30: Acknowledge (ACK). 0x31: Non-acknowledge (NACK).
10	Check Sum	WORD	Check Sum (byte addition) OFFSET[0]+…+OFFSET[9]=Check Sum

Acknowledge Packet Description

Offset	Content	Size	Description
0	0x5A	BYTE	Data start code1
1	0xA5	BYTE	Data start code2
2	Device ID	WORD	Device ID: default is 0x0001, always fixed
4	Data	N BYTES	N bytes Data The size is pre-defined per protocol stage
4+N	Check Sum	WORD	Check Sum (byte addition) OFFSET[0]+…+OFFSET[4+N-1]=Check Sum

Data Packet Description

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Command Listing

All communication between external hardware, which in most cases will be a microcontroller, and the fingerprint module is executed via the UART interface using a fixed set of commands. The full set of commands along with their details are set out in the following chapters.

The following table provides a summary of all available commands.

Number HEX	Alias	Description
01	Open	Initialisation
02	Close	Termination
03	UsbInternalCheck	Check if the connected USB device is valid
04	ChangeBaudrate	Change UART baud rate
05	SetIAPMode	Enter IAP Mode In this mode, FW Upgrade is available
12	CmosLed	Control CMOS LED
20	GetEnrollCount	Get enrolled fingerprint count
21	CheckEnrolled	Check whether the specified ID is already enrolled
22	EnrollStart	Start an enrollment
23	Enroll1	Make 1st template for an enrollment
24	Enroll2	Make 2nd template for an enrollment
25	Enroll3	Make 3rd template for an enrollment, merge three templates into one template, save merged template to the database
26	IsPressFinger	Check if a finger is placed on the sensor
40	DeleteID	Delete the fingerprint with the specified ID
41	DeleteAll	Delete all fingerprints from the database
50	Verify	1:1 Verification of the capture fingerprint image with the specified ID
51	Identify	1:N Identification of the capture fingerprint image with the database
52	VerifyTemplate	1:1 Verification of a fingerprint template with the specified ID
53	IdentifyTemplate	1:N Identification of a fingerprint template with the database
60	CaptureFinger	Capture a fingerprint image(256x256) from the sensor
61	MakeTemplate	Make template for transmission
62	GetImage	Download the captured fingerprint image(256x256)
63	GetRawImage	Capture & Download raw fingerprint image(320x240)
70	GetTemplate	Download the template of the specified ID
71	SetTemplate	Upload the template of the specified ID
72	GetDatabaseStart	Start database download – obsolete
73	GetDatabaseEnd	End database download, – obsolete
80	UpgradeFirmware	Firmware Upgrade
81	UpgradeISOCDImage	Not supported
30	Ack	Acknowledge.
31	Nack	Non-acknowledge.

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Command Description Details

All of the GTM fingerprint modules share a common set of commands. However within a subset of commands there are certain parameters that must also be transmitted., such as fingerprint ID and certain data for that particular module. The value of these parameters differ according to specific part numbers. The following table shows this command subset and the relevant parameters that need to be defined within these commands.

Command Name	Parameter Type	GTM Device		
		5110C2/C21	5110C3/C31	5110C5/C51
CheckEnrolled	ID	0~19	0~199	0~1999
EnrollStart	ID	0~19	0~199	0~1999
DeleteID	ID	0~19	0~199	0~1999
Verify	ID	0~19	0~199	0~1999
VerifyTemplate	ID	0~19	0~199	0~1999
	Data	506	498	498
IdentifyTemplate	Data	506	498	498
MakeTemplate	Data	506	498	498
GetImage	Data	240×216	258×202	258×202
GetRawImage	Data	240×216	160×120	160×120
GetTemplate	ID	0~19	0~199	0~1999
	Data	506	498	498
SetTemplate	ID	0~19	0~199	0~1999
	Data	506	498	498

The following describes each command in detail.

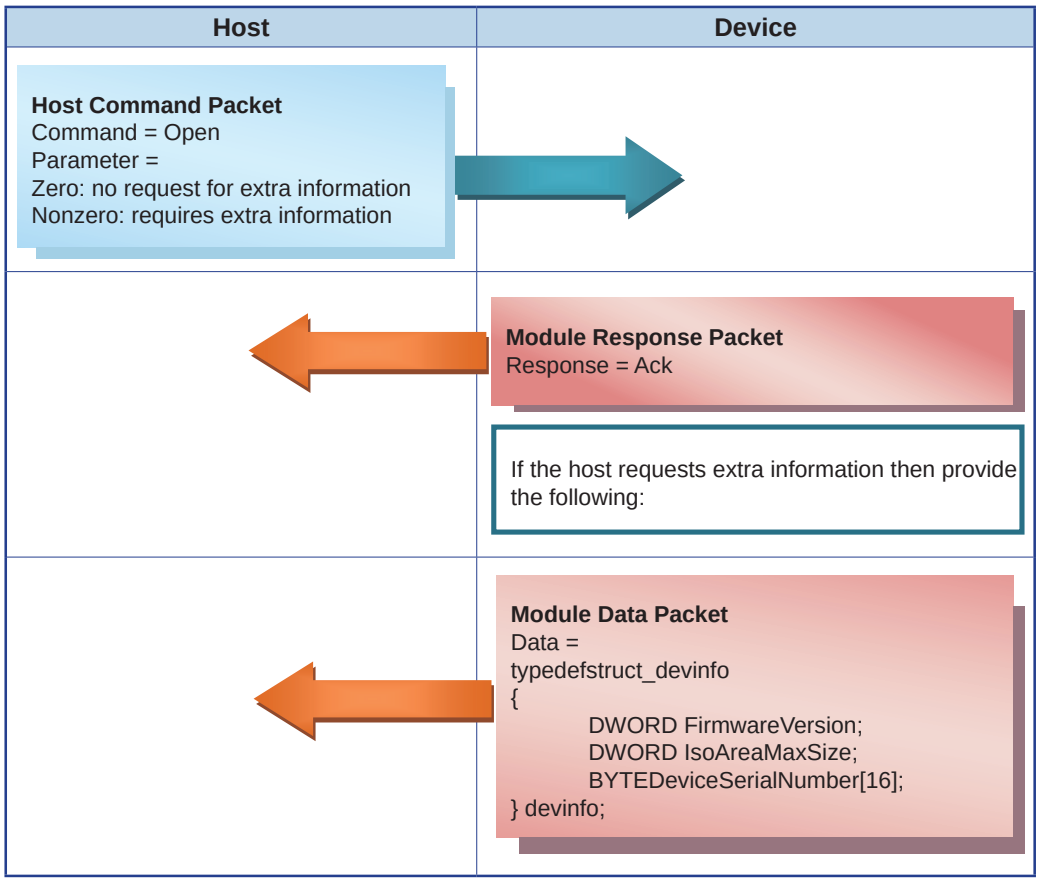
Initialization (Open)

The Open command is used for module initialization and to obtain the module static information.

Field	Sample	Description
FirmwareVersion	FirmwareVersion: 20120225	Firmware version
IsoAreaMaxSize	IsoAreaMaxSize: 0KB	Maximum ISO CD image size
DeviceSerialNumber	DeviceSN: EF15EF4016C66250-888F1A41	Unique device serial number

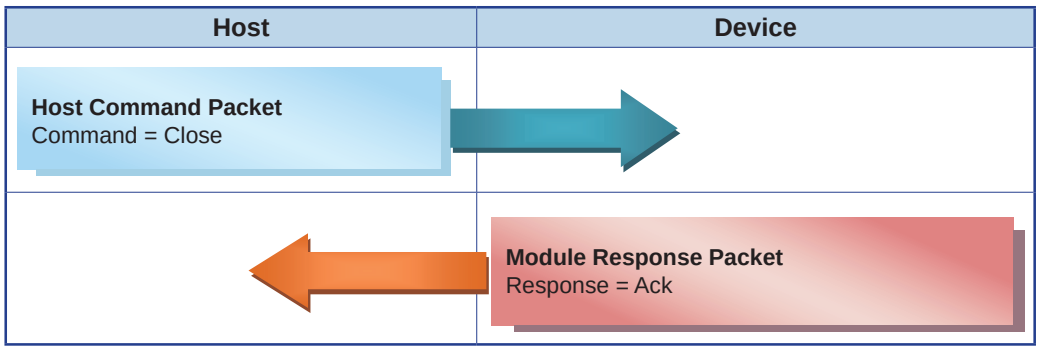
Description of devinfo structure

If the Module's Serial Number is zero, it must be noted that the device may not operate correctly.



Termination (Close)

The Close command results in no action.



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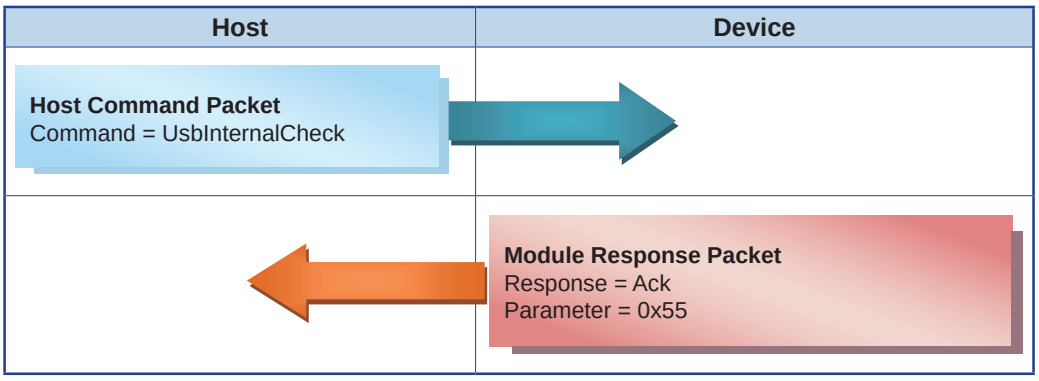
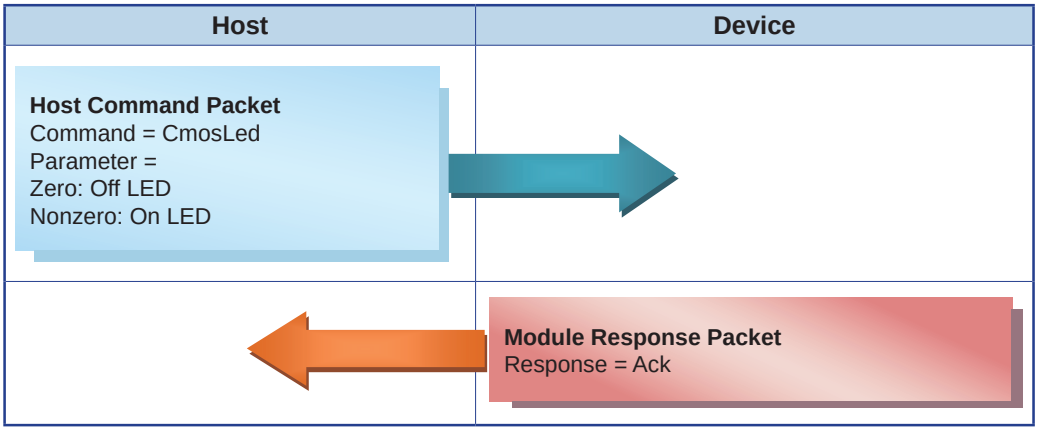
Fast device search (UsbInternalCheck)

Operation is similar to a removable CD drive. However if there is another removable CD in the system, it may take a longer time to achieve a connection. The UsbInternalCheck command is used to overcome this problem by fast searching for the device.



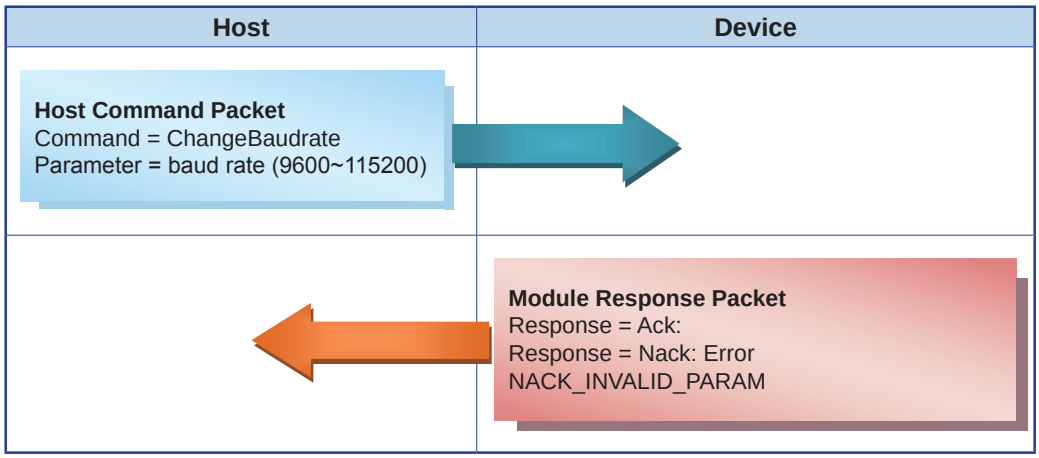
CMOS LED control (CmosLed)

The CMOS (Sensor) LED default condition is an OFF condition. However, note that during the boot process, the LED will flash once, providing an indication that the LED is working. So it is important to send an LED ON command before any data capture actions are executed.

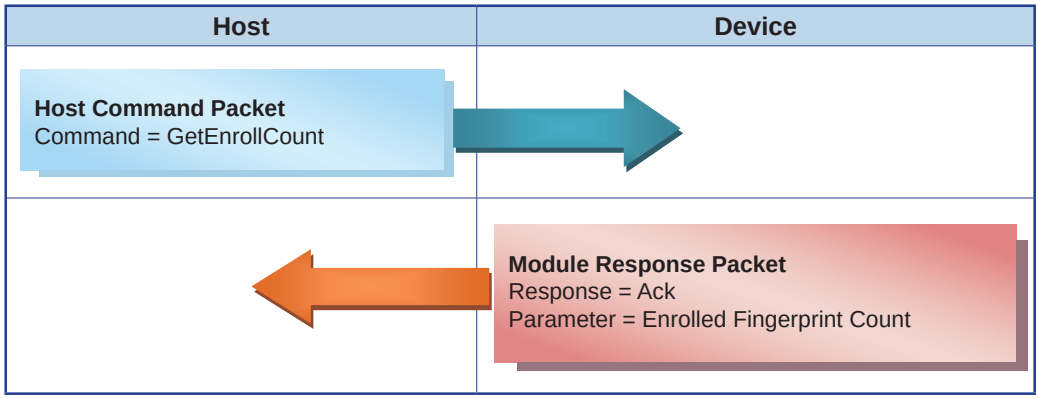


Changing the UART baud rate (ChangeBaudrate)

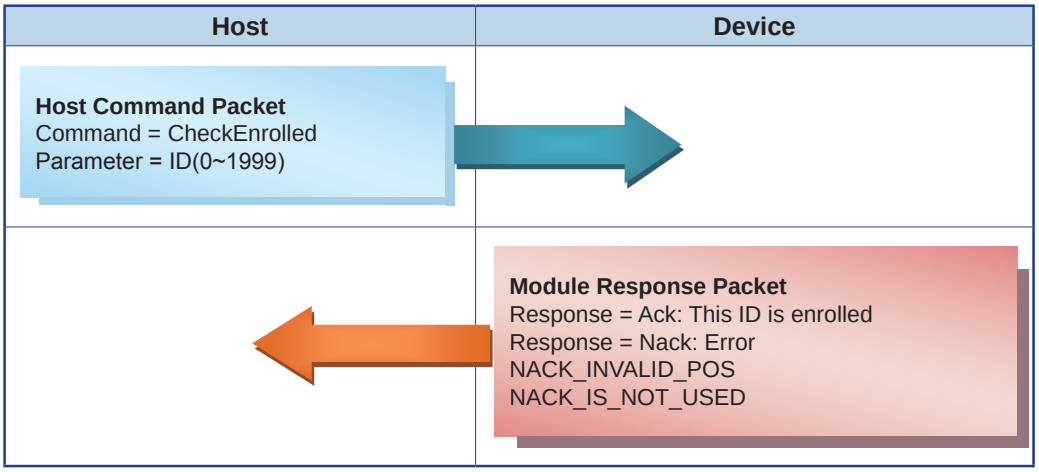
The UART baud rate can be changed using this command during normal running. After power on the module will be initialised to a 9600 bps UART baud rate.



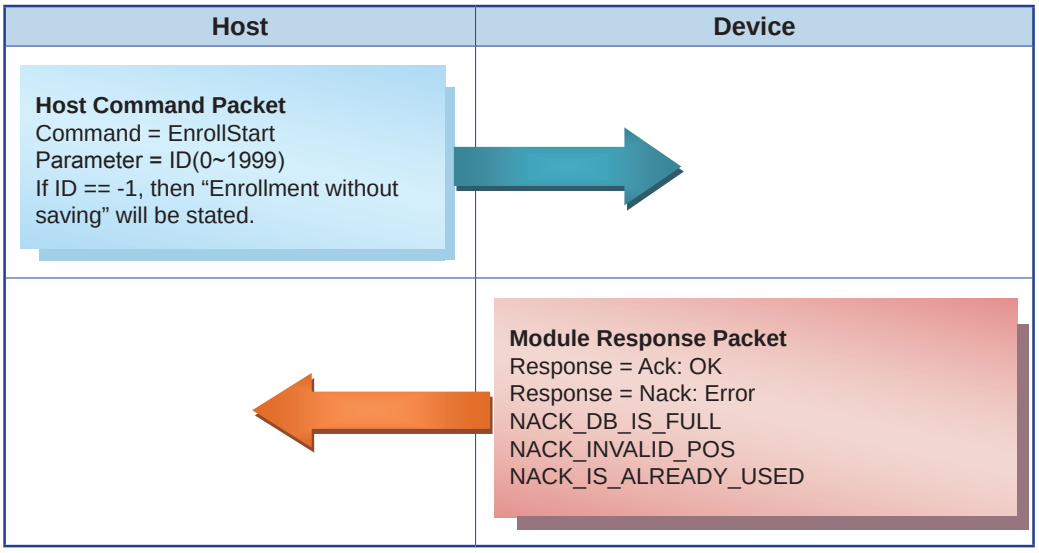
Obtain enrolled fingerprint count (GetEnrollCount)



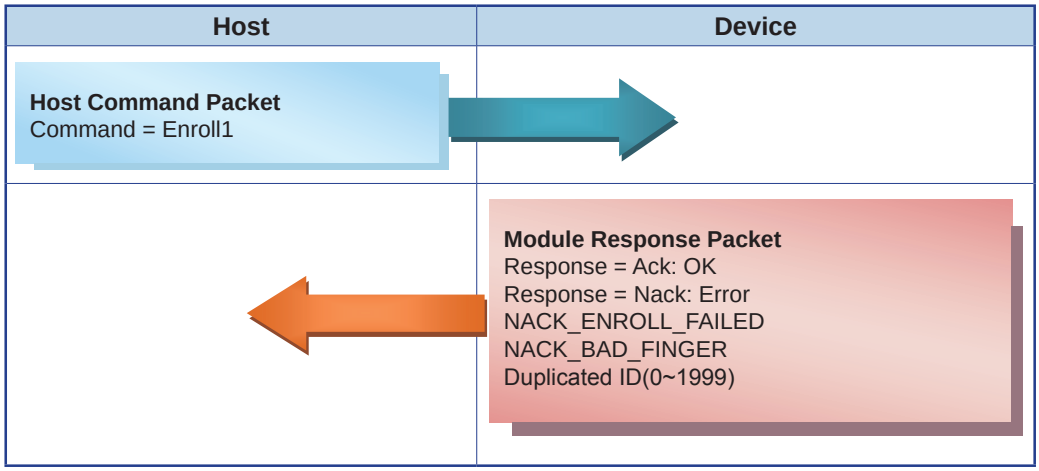
Check enrollment status (CheckEnrolled)



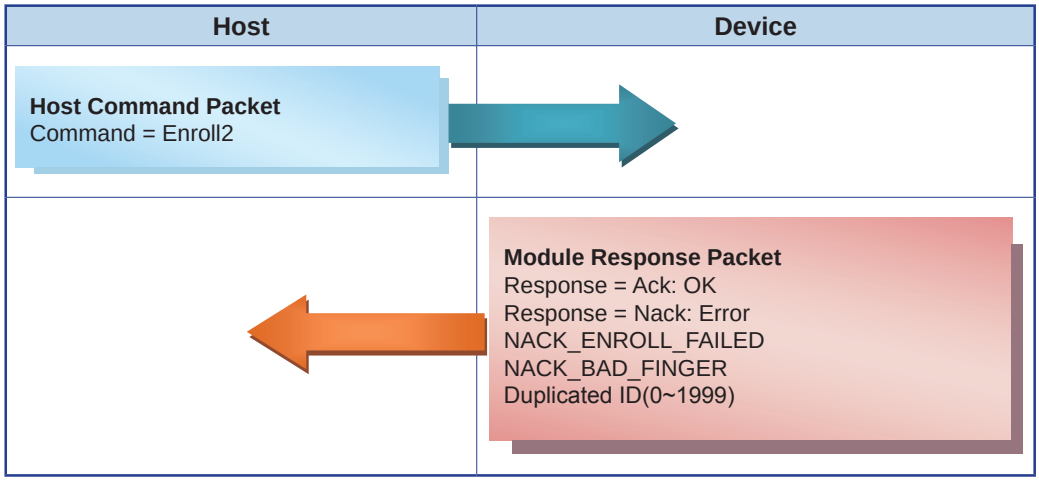
Start an enrollment process (EnrollStart)



Generate the first enrollment template (Enroll1)

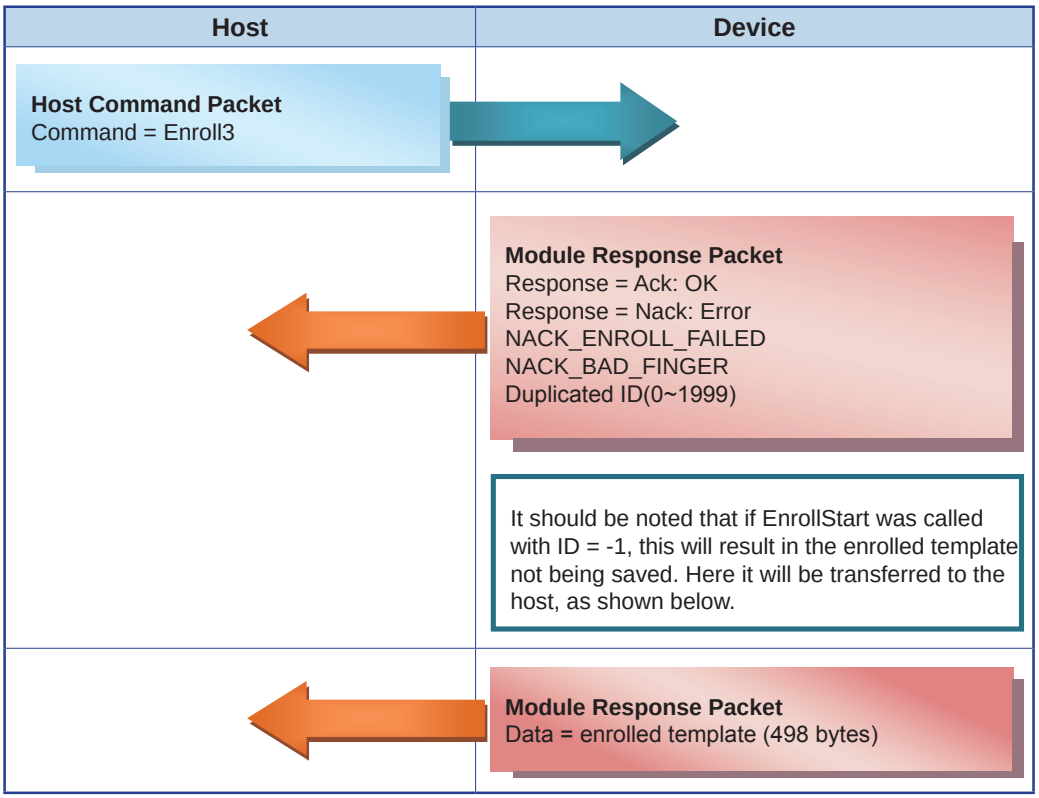


Generate the second enrollment template (Enroll2)



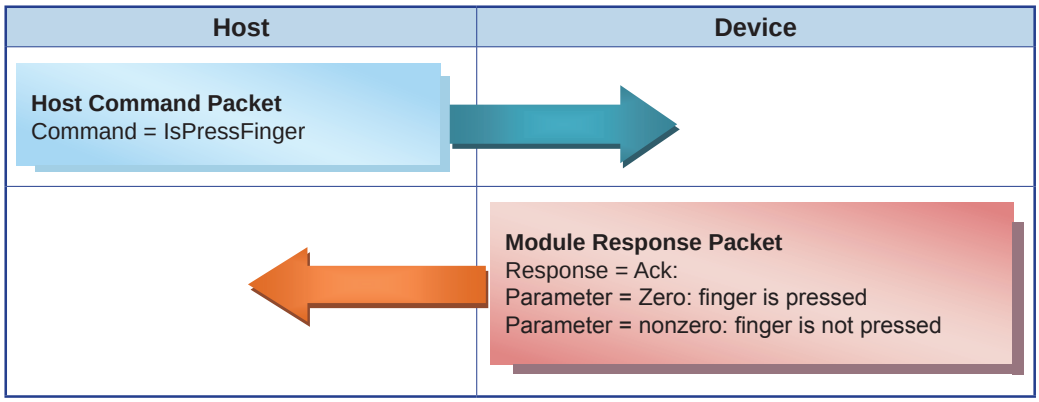
Generate the third enrollment template and then merge the three templates (Enroll3)

To implement a full fingerprint enrollment process, the host must send out the previous four commands. More details regarding this is provided in a different section.

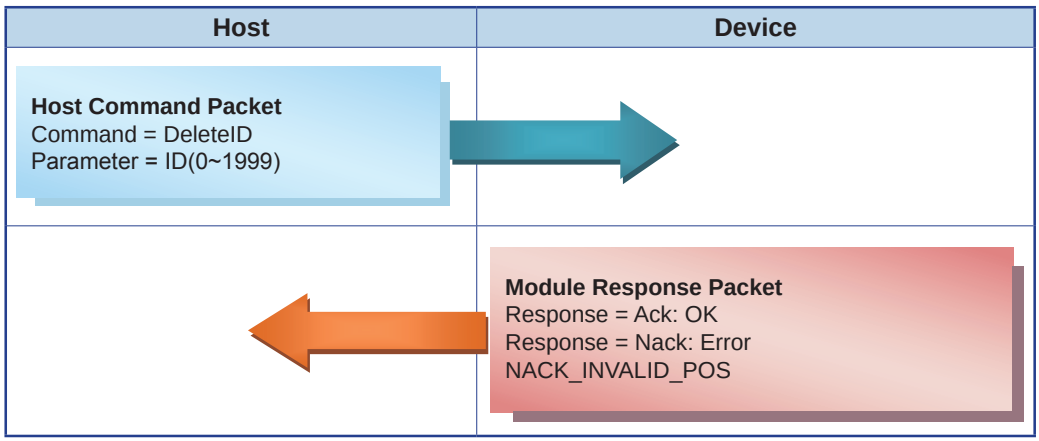


Check the finger press status (IsPressFinger)

During the enrollment process, this command is used during the time when the host is waiting for the finger to be removed.



Delete a single fingerprint (DeleteID)



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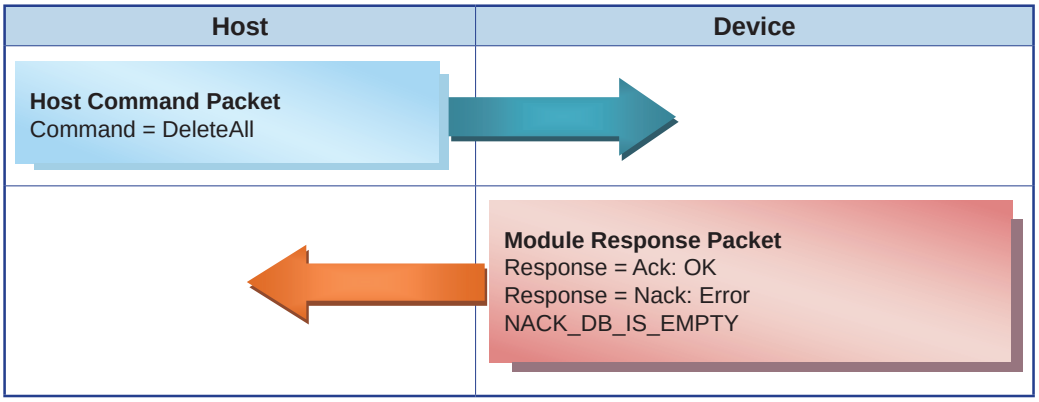
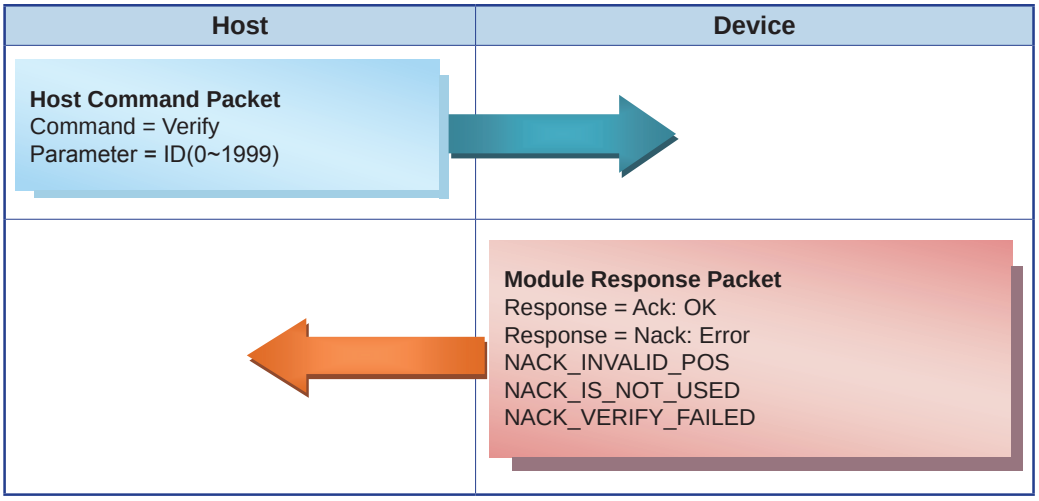
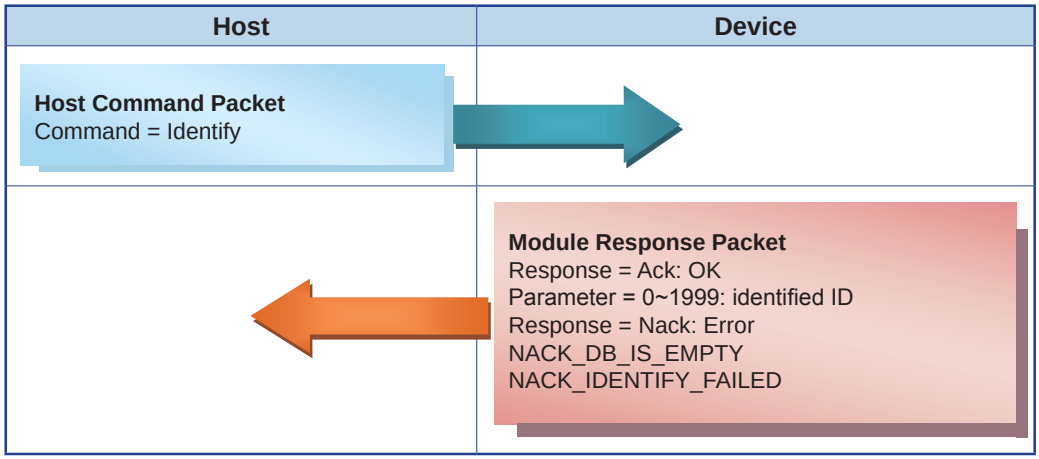
Delete all fingerprints (DeleteAll)



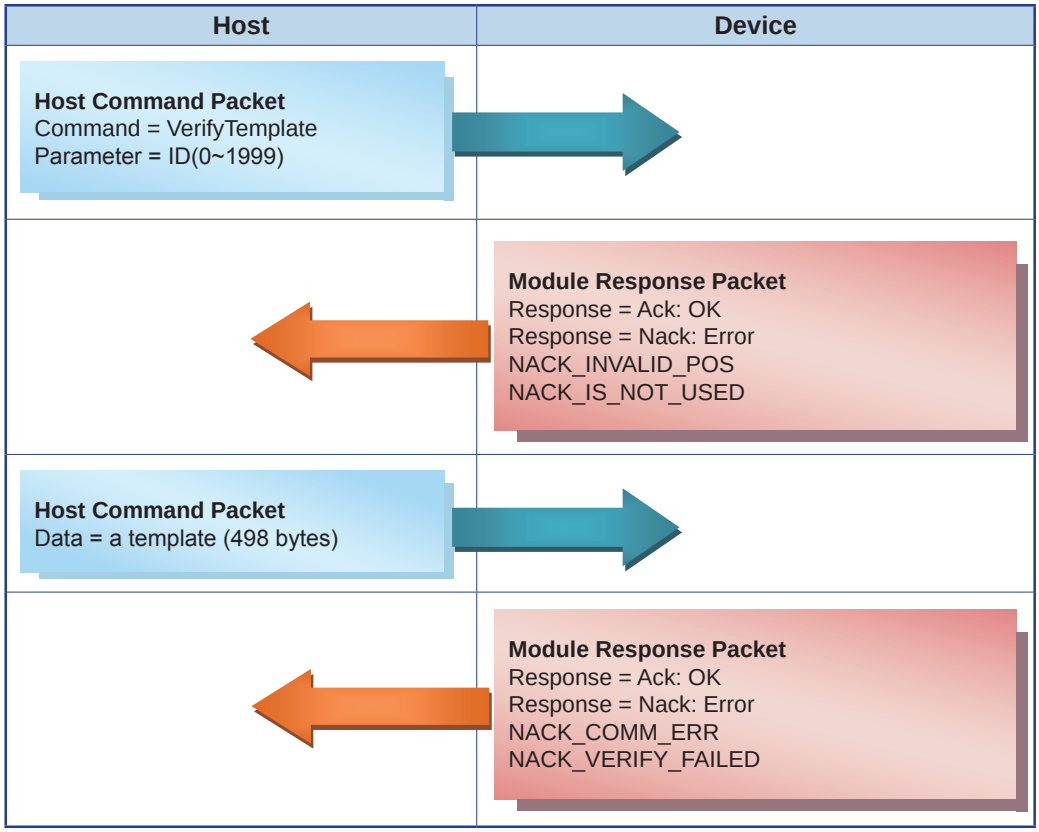
1:1 Verification (Verify)



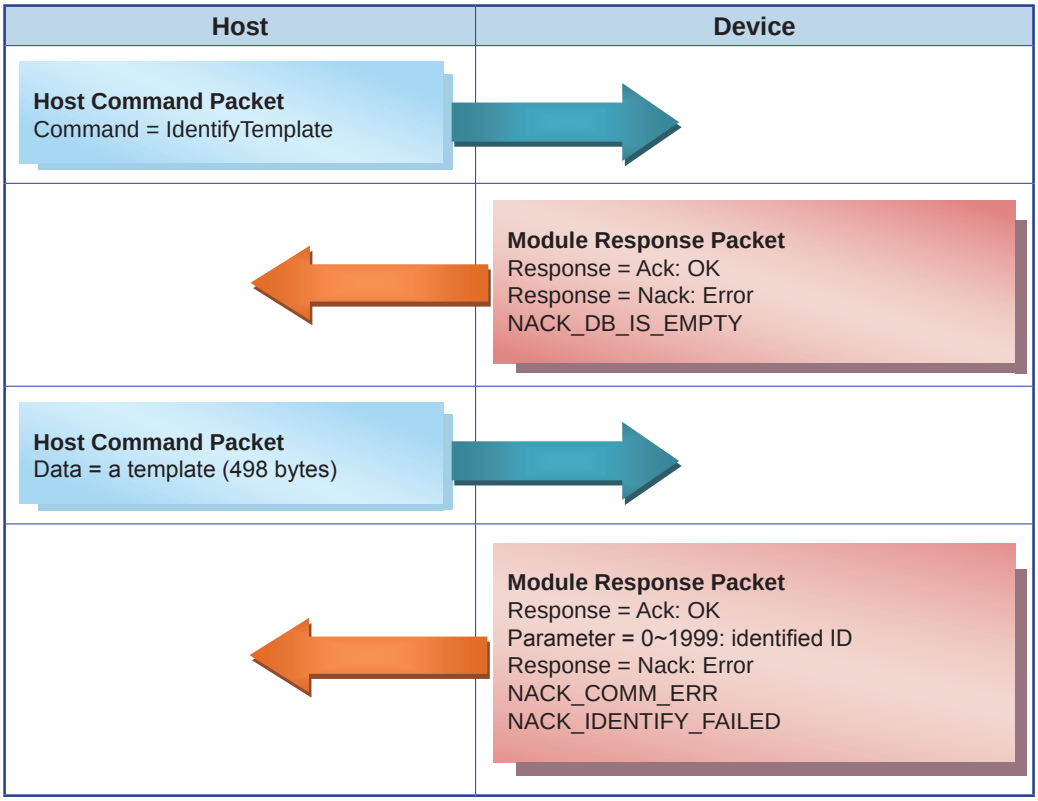
1:N Identification (Identify)



1:1 Template Verification (VerifyTemplate)

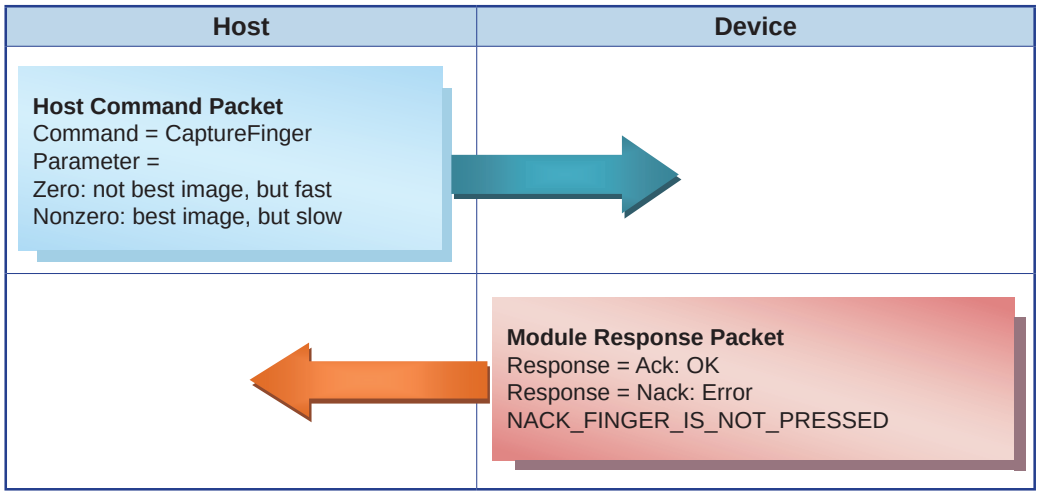


1:N Template Identification (IdentifyTemplate)



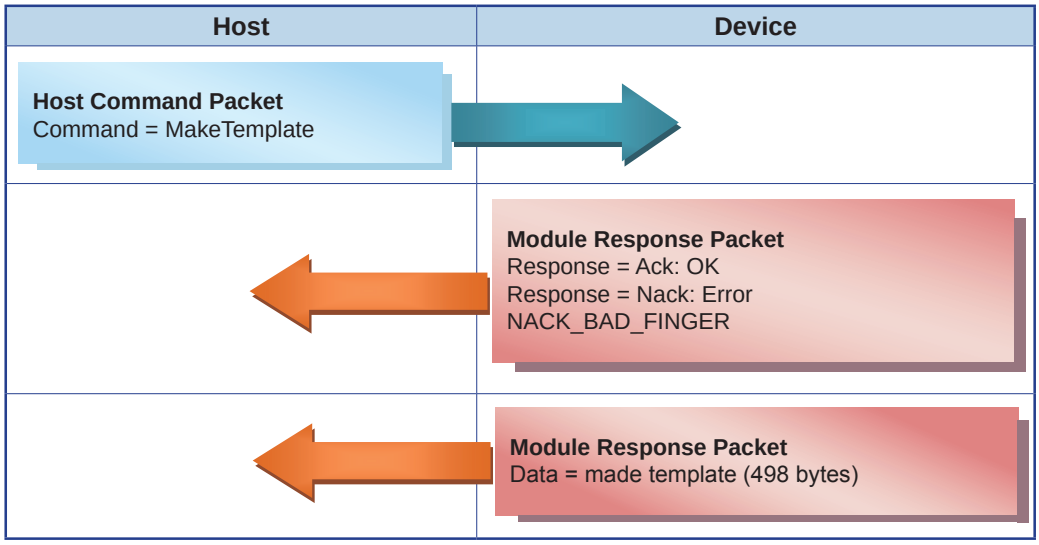
Capture fingerprint (CaptureFinger)

The raw fingerprint image data is captured from the sensor using this command. As the fingerprint algorithm is setup to process a 450dpi 256×256 image, the captured image is converted to a 256×256 image before algorithmic processing. If no finger is detected then the command will return a non-acknowledge.

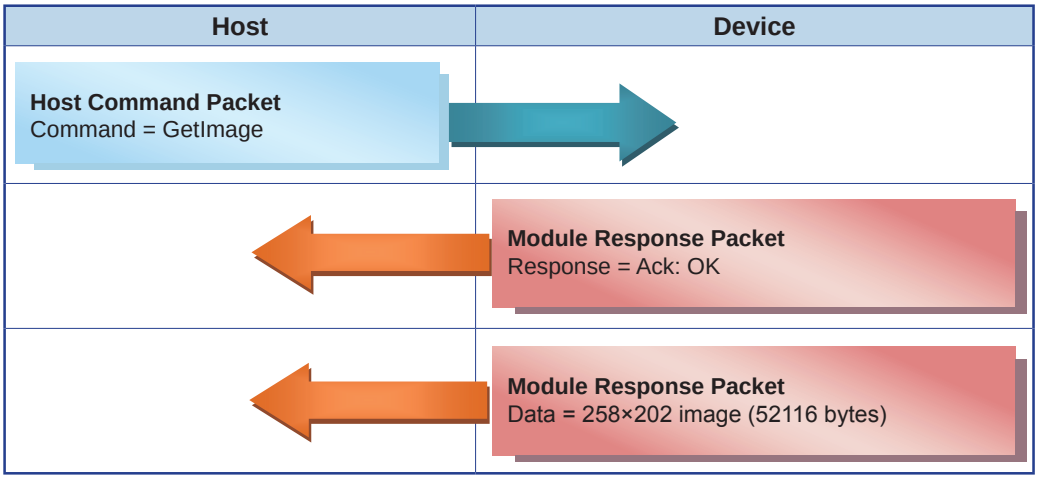


Generate a Template (MakeTemplate)

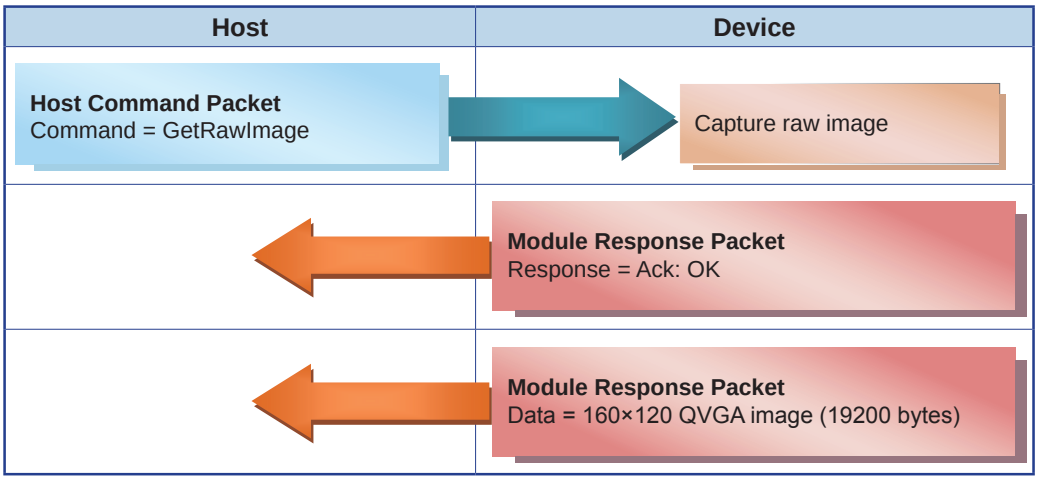
This command is used to generate a template for transmission. Before sending this command a CaptureFinger command should have been previously sent. The template should not be used for registration.



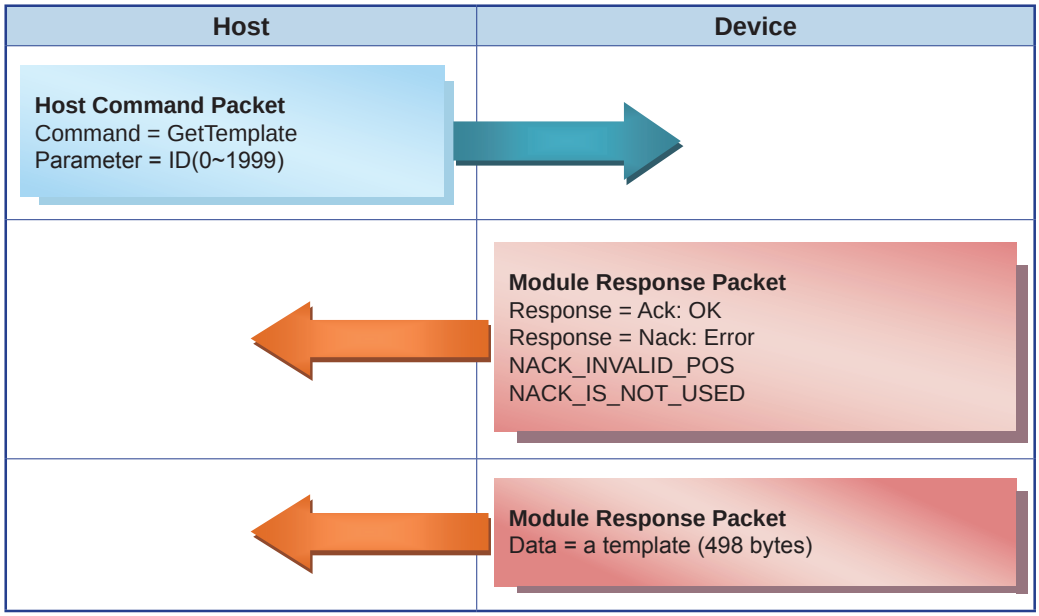
Obtain fingerprint image (GetImage)



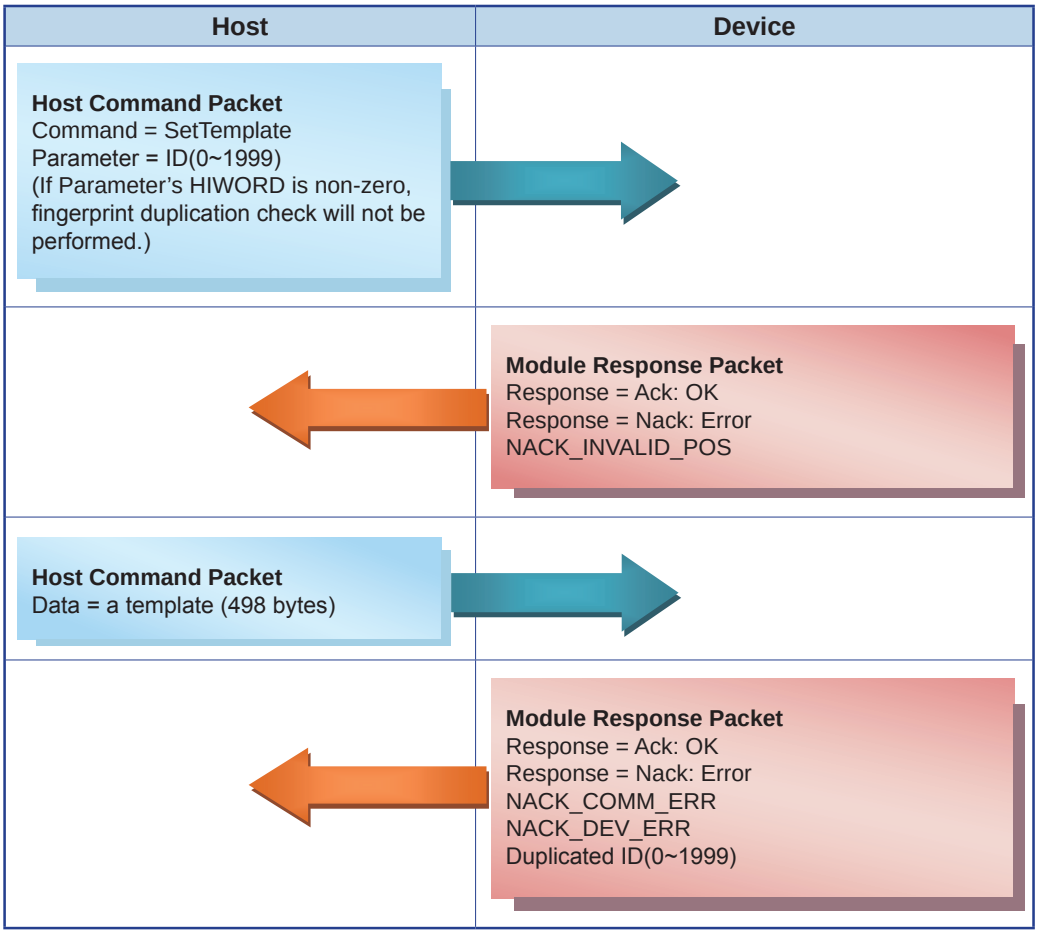
Obtain raw image (GetRawImage)



Obtain template (GetTemplate)

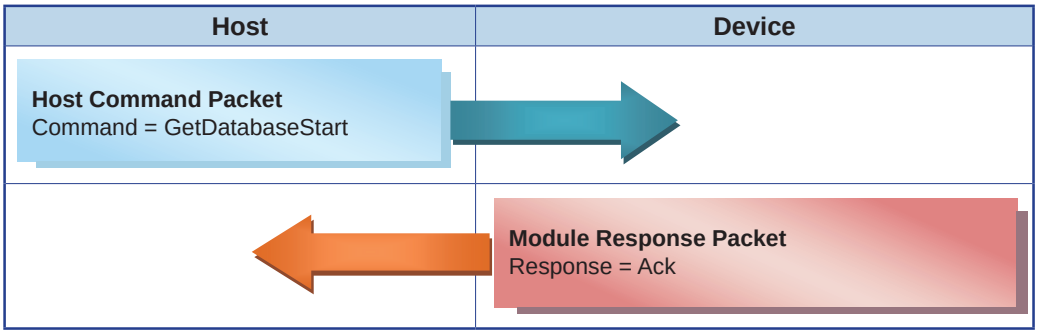


Set template (SetTemplate)



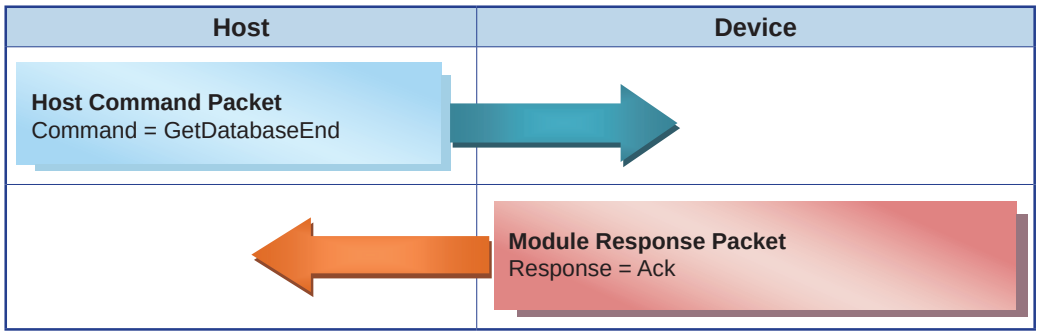
Start a database download – obsolete command (GetDatabaseStart)

This command is now obsolete, no longer required and therefore results in no action. It was formerly used for RS232 interface communication purposes and for historical reasons remains.



End database download – obsolete command (GetDatabaseEnd)

This command is now obsolete, no longer required and therefore results in no action. It was formerly used for RS232 interface communication purposes and for historical reasons remains.



Upgrade Firmware (UpgradeFirmware)

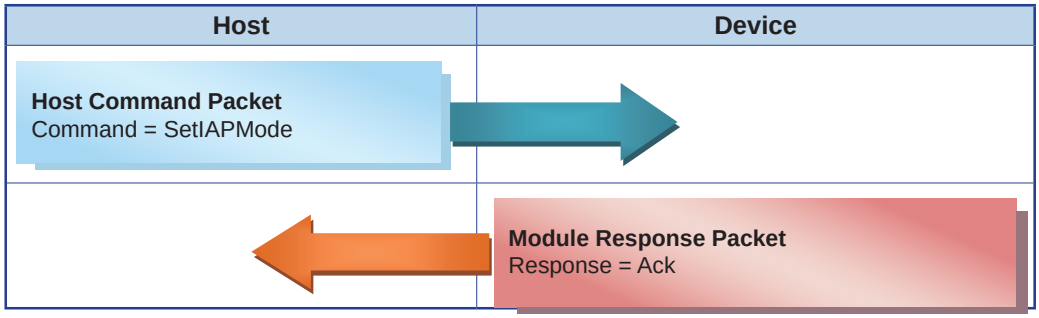
Not supported

Upgrade the ISO CD Image (UpgradeISOCDImage)

Not supported

Set IAP Mode (SetIAPMode)

This command is used to make the module enter into the IAP Mode. When in the IAP mode a FW upgrade can be executed.



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Error Codes

When the response to any command is a Non-acknowledge, then an error code will be generated as shown in the accompanying table.

NACK Parameter	Value	Description
NACK_TIMEOUT	0x1001	Obsolete, capture timeout
NACK_INVALID_BAUDRATE	0x1002	Obsolete, Invalid serial baud rate
NACK_INVALID_POS	0x1003	The specified ID is not between 0~19
NACK_IS_NOT_USED	0x1004	The specified ID is not used
NACK_IS_ALREADY_USED	0x1005	The specified ID is already used
NACK_COMM_ERR	0x1006	Communication Error
NACK_VERIFY_FAILED	0x1007	1:1 Verification Failure
NACK_IDENTIFY_FAILED	0x1008	1:N Identification Failure
NACK_DB_IS_FULL	0x1009	The database is full
NACK_DB_IS_EMPTY	0x100A	The database is empty
NACK_TURN_ERR	0x100B	Obsolete, Invalid order of the enrollment (The order was not as: EnrollStart → Enroll1 → Enroll2 → Enroll3)
NACK_BAD_FINGER	0x100C	Too bad fingerprint
NACK_ENROLL_FAILED	0x100D	Enrollment Failure
NACK_IS_NOT_SUPPORTED	0x100E	The specified command is not supported
NACK_DEV_ERR	0x100F	Device Error, especially if Crypto-Chip is trouble
NACK_CAPTURE_CANCELED	0x1010	Obsolete, The capturing is canceled
NACK_INVALID_PARAM	0x1011	Invalid parameter
NACK_FINGER_IS_NOT_PRESSED	0x1012	Finger is not pressed
Duplicated ID	0 – 19	There is duplicated fingerprint (while enrollment or setting template), This error describes just duplicated ID

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Capturing a Fingerprint Image

A fingerprint image can be read and stored by transmitting a series of commands to the fingerprint module as follows.

IsPressFinger is used to check whether a finger has been placed on the sensor. This function is used during enrollment.

CaptureFinger is used to capture the fingerprint image. If a finger has not been placed on the sensor, it will return an error. If the function is successful, the device's internal RAM will store the data as a valid fingerprint image, ready for use by subsequent commands. If the host issues other command, the fingerprint image will be used and destroyed.

GetRawImage is used to capture a raw live image. It will not check if a finger has been placed on the sensor. This function is used for debug or calibration.

Identifying and Verifying a Fingerprint Image

After capturing a fingerprint image it then has to be identified and verified as follows.

Identify and IdentifyTemplate perform a 1: N matching operation.

Verify and VerifyTemplate perform a 1: 1 matching operation.

Before the image-related matching functions, Identify and Verify, are called, the host must first call CaptureFinger.

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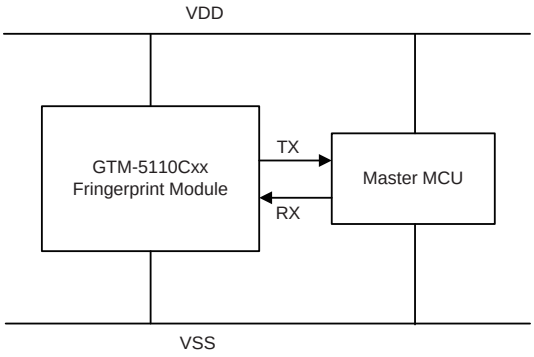
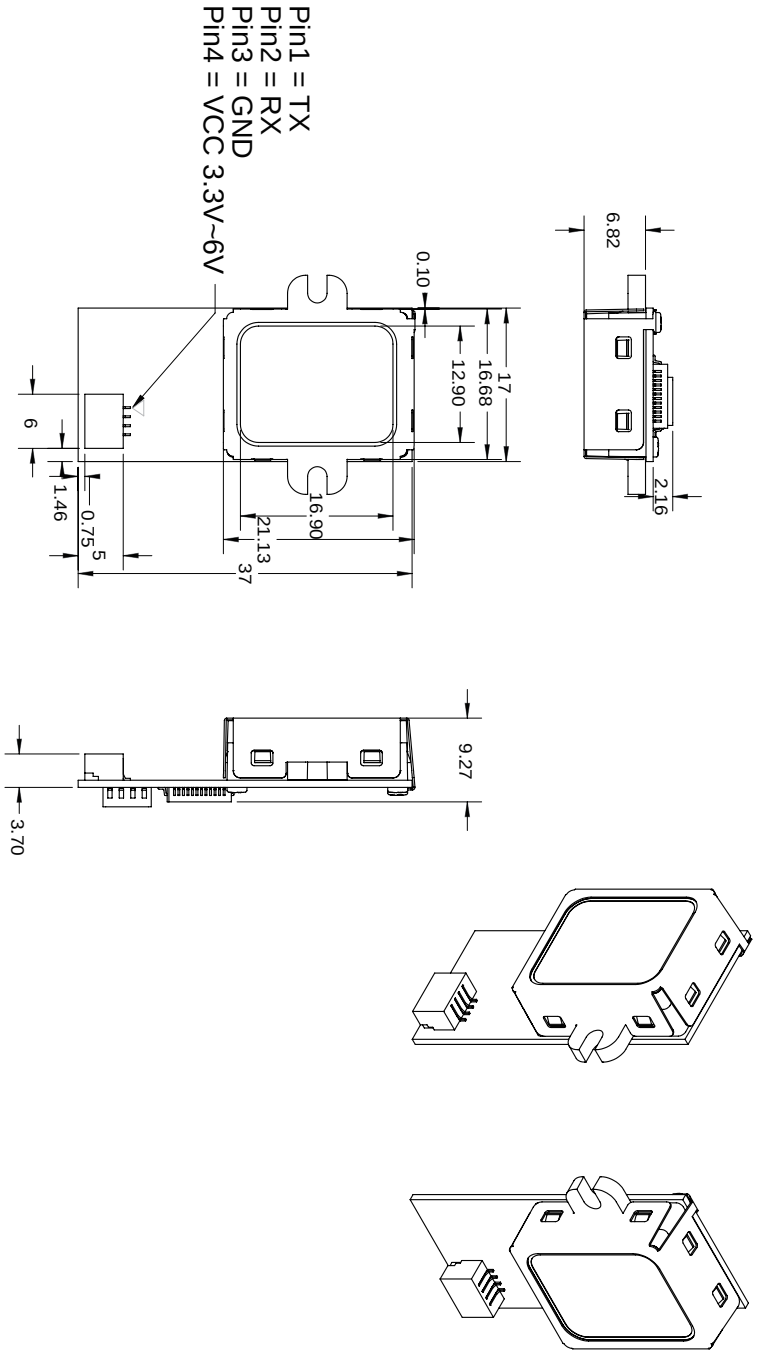
10 Application Circuit

As the GTM series of Fingerprint Modules are fully integrated requiring no external components for their operation, the addition of an external MCU, communicating via the UART interface is all that is required to implement a fingerprint recognition system.



11 Mechanical Specifications



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Note that Holtek's fingerprint recognition products have been designed in conjunction with Gingy Technology.